



Installation Practices and NEC Compliance for Solar Photovoltaic Systems

John C. Thompson
National Application Engineer
Eaton Corporation Electrical Group
Phone: 678-438-0241
email: johncthompson@eaton.com

Topics

- Safety
- Grounding
- Ratings and Labels
- Codes and Standards

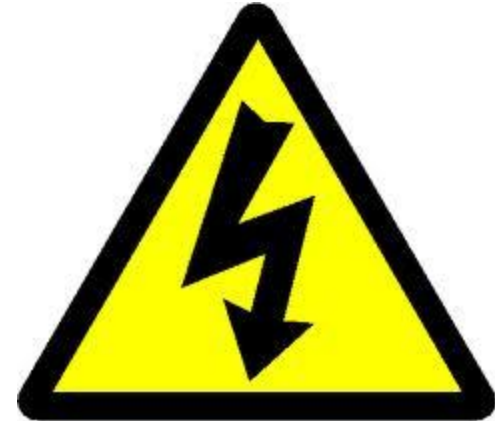
Safety

Personnel

- Your Safety Plan
- Your Equipment/Tools
- The Job Site
- Arc Flash Safety

Equipment

- Product Ratings
- Listed and Labeled
- Periodic Inspections



Typical Examples of Safety Issues

Common Problem Areas



- Fuse Holders Not Closed
- Covers Not Secured
- Loose Connections
- Conductor & Fuse Sizing Issues
- Bonding Bushings May Be Required
- Mounted Incorrectly
- Output Circuit In Metallic Raceway
- Source Circuit Protection Readily Accessible
- Thermal Imaging Can Be Useful
- Misapplication of NEMA Rated Enclosures
- Rodent Damage

This issue is obvious but others may not be as such. Review each installation looking at your surroundings.



690.31(A) Photovoltaic source and output circuits greater than 30 volts installed in readily accessible locations, circuit conductors shall be installed in a raceway”



Ground Mounted Array DC circuit conductors are located in a readily accessible location Add fencing or netting around the array to make the array “accessible” only

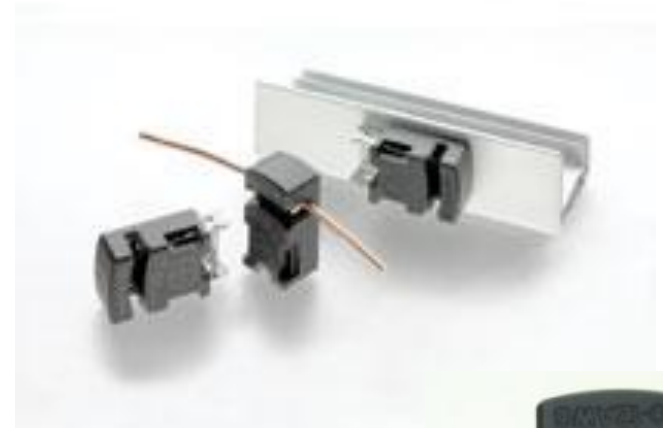
This is NOT Acceptable – Does Not Effectively Make This Array Only “Accessible”



Grounded vs. Ungrounded Applications

- Traditionally, the US has used only grounded DC systems
- Ungrounded systems are more popular in Europe and Japan
- Ungrounded systems result in higher system efficiencies
- You May Come Across Ungrounded Systems
- 2005 NEC Added Section 690.35,
“Ungrounded Photovoltaic Power Systems”

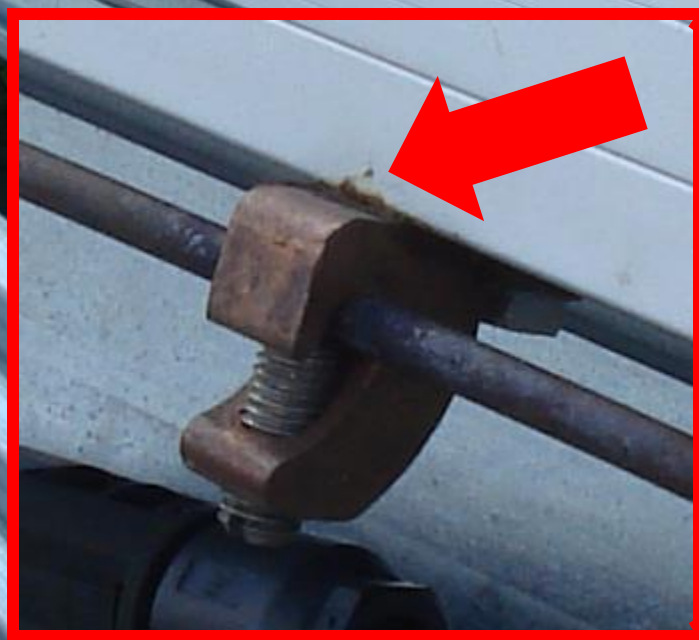
Grounding & Bonding



Pay Close Attention as necessary components may be in the back of the bonding mechanism



Incorrect hardware looks great when first installed
Time will reveal the corrosion that degrades the bond



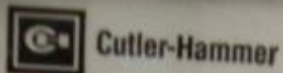
Challenges

- Most rails and frames are anodized aluminum
- The surface is non-conductive
- Surface is enough to prevent a good electrical connection with simple contact
- Surface is not insulating enough to protect people who touch it
- Contact between aluminum and copper wire causes galvanic corrosion

Ratings & Product Applications

- Ensure DC Ratings on Overcurrent Protective Devices
- PV Systems Introduce Reverse Power Feed Situations





Cutler-Hammer

Industrial
Circuit Breaker
Frame

HJD-DC

250 Amp Max. 3 Pole
600 VDC

Cat. HJDDC3250F
Style 1431D3200

Use Only With
Thermal Magnetic Trip Unit

Terminal Cat. No.	Wire Size	Torque lb. in.
CU/AL TA250KB	4 - 350	275
CU ONLY T250KB	4 - 350	180

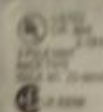
60/75°C Wire -
125 Amp & Lower Only

Westinghouse

Westing

ON/I

ON/I



Cir.
No.



6641 C83 H30

Modification Code

HJD-DC Interrupting Capacity

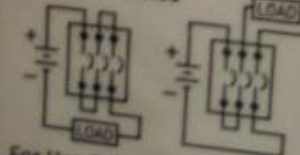
Poles In Series	Max. VDC	Amps	ms*
1	125	42k	8
2	250	42k	8
3	600	35k	8

* ms = Time Constant

This Frame May Be Used With
UPS Systems That Need The
Following 3 Poles In Series
Rating -

Nom. VDC	Max. VDC	Amps	ms*
500	600	35k	8

3 Poles In Series



For Use On Ungrounded
Systems Only

Cutler-Hammer
Made in U.S.A.

Codes and Standards

Document	Title
NFPA 70 – Article 690	Solar Photovoltaic (PV) Systems
NFPA 70E	Electrical Safety in the Workplace
UL 98	Enclosed and Dead-Front Switches
UL 1703	Flat-Plate Photovoltaic Modules and Panels
UL 1741	Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 891	Switchboards
UL 67	Panelboards
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

National Electrical Code

Article 690 – Solar Photovoltaic (PV) Systems

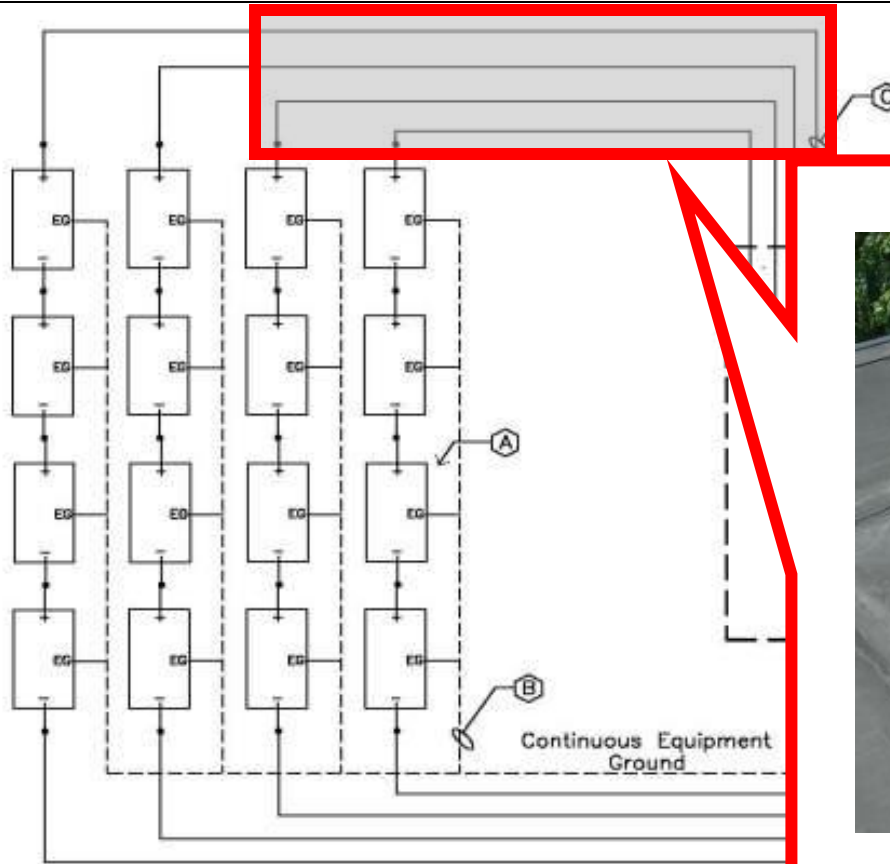
- Connection to Other Sources
- Circuit Requirements
- Disconnecting Means
- Wiring Methods
- Grounding
- Marking
- Storage Batteries



"Line" and "Load" Markings



Sample PV System



NOTES:

A. Module wiring per 690.8 90°C cable
 B. Equip. grd. conductor sized at 1.25 X Isc
 C. Ampacity 1.56 X Isc plus temp. derating
 D. Box wiring methods per 690.31
 E. OC protection per 690.8 (1.56 X Isc)
 F. DC disconnect per 690.14, 690.53, 690.7
 G. Grd. fault protection per 690.5
 H. Inverter: comply with 690.47(C).1 & UL1741

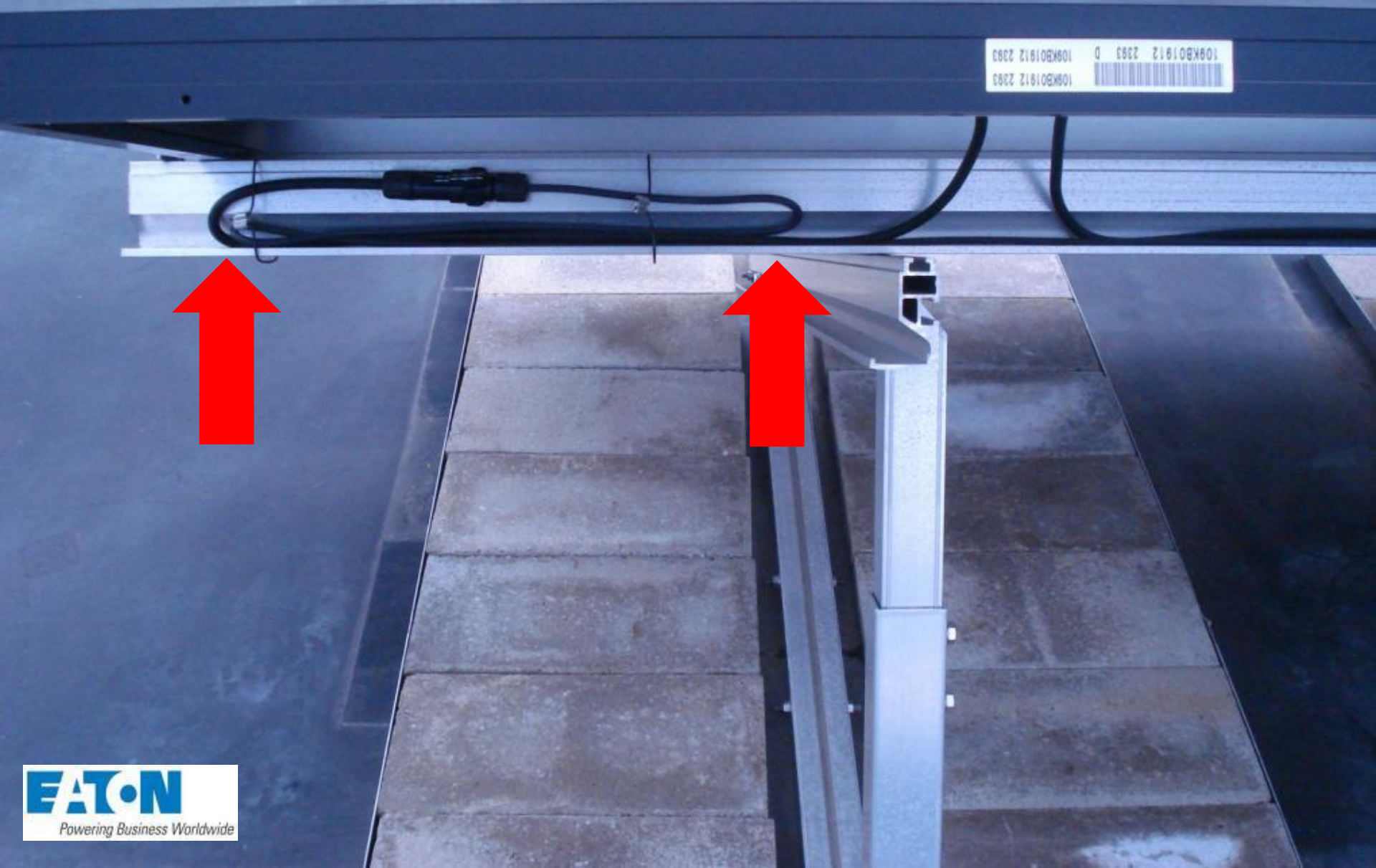
I. AC output device per 690.8
 J. Net meter usually not required except for City of Banning
 K. Located within 10' of service 690.14, 690.17, 690.53
 L. PV breaker per 690.8 and 690.14
 M. Bus ampere rating X 1.20
 N. Utility Service Main CB

Supply Circuits



**Equipment Grounding Conductor
 Sized at 1.25 X Isc (690.45(A))
 Ampacity is 1.56 X Isc (690.8(B))
 Don't Forget Derating (310.15)**

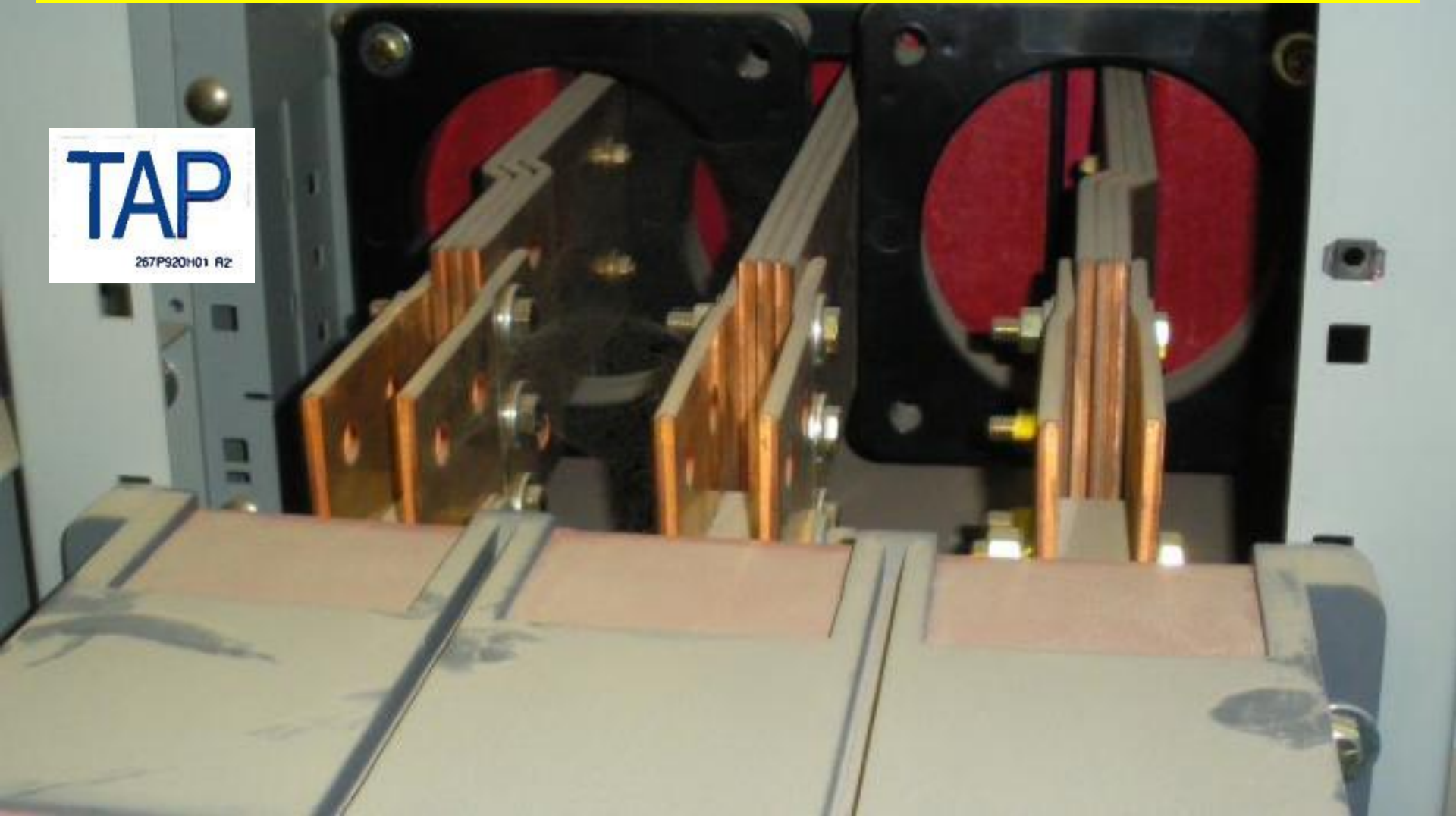
Over zealous wire management may violate bending radius requirements



This is NOT an Approved Lug For This Application
Refer to the Manufacture for Approved Methods [110.3(B)]
Module Mfgs will Have Suggested Grounding Methods (250.8)



The Existing Holes In This Bus Are NOT Intended For Taps
Unless Labeled As Such





QUESTIONS?